



Operational Experience of the Fermilab Vertical Test Facilities

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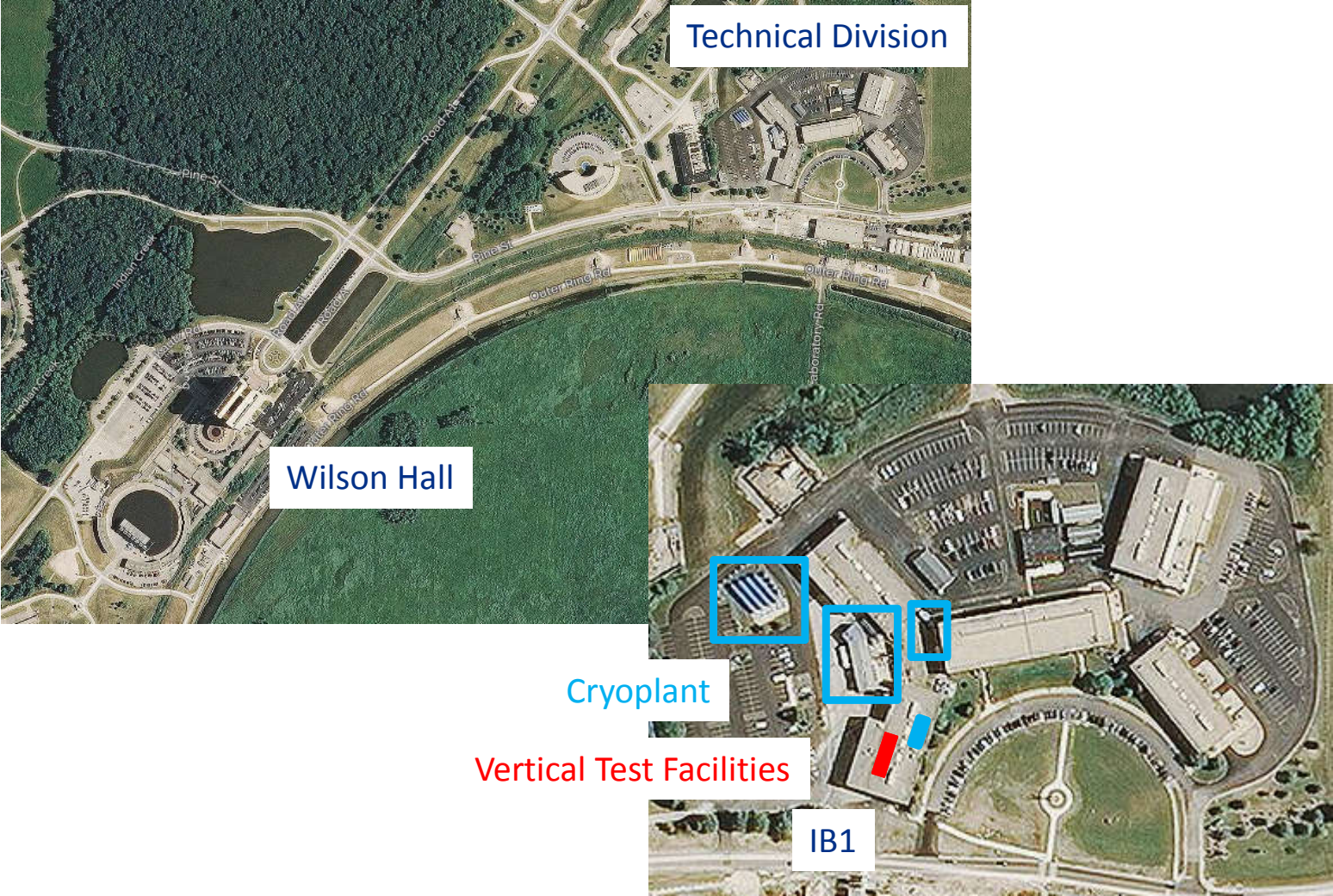
2016 Workshop on Cryogenic Operations

27 October 2016

Agenda

- Overview of Industrial Building 1 (IB1)
 - Cryogenic Infrastructure
 - Vertical Test Facilities
- Cryogenic Infrastructure Improvements
- Vertical Test Facilities Improvements
- Operations Issues and Resolutions

Fermilab

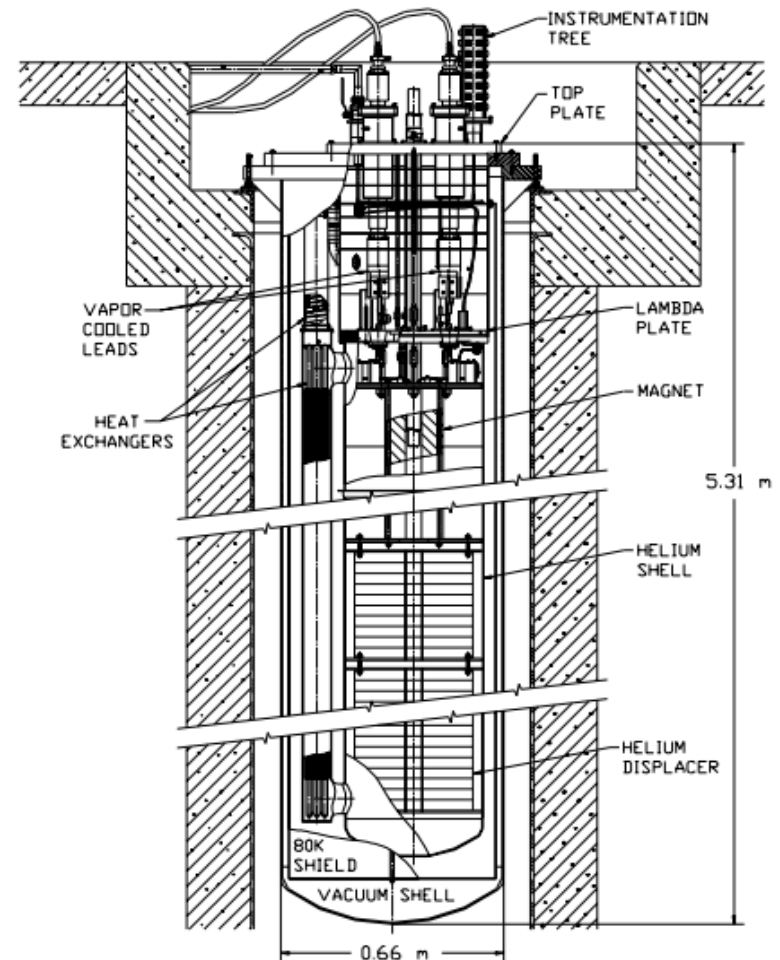


IB1 Cryogenic Infrastructure

- CTI-Sulzer 1500 liquefier
 - 3-stream cold box with 2 turboexpanders and LN₂ precooling
 - > 300 liquid liters/hr @ 23 psia
 - Compressor skid with two Sullair C25L oil-flooded rotary screw compressors (1710 cfm each @ 3550 rpm)
 - 10,000 liter LHe storage dewar
 - Six 30,000 gallon GHe storage tanks
 - 10,000 gallon LN₂ storage dewar
- Supports Vertical Test Facilities (the focus of this talk) and Horizontal Test Facilities (cryostated magnets (Tevatron, SSC, LHC) and HTS current leads)

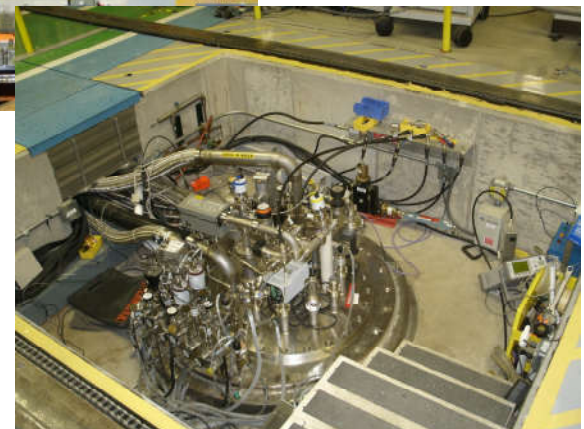
Vertical Test Facilities

- Vertical Magnet Test Facility (VMTF)
 - Two-bath vertical dewar
 - 4.5 K saturated
 - 1.9 K subcooled
 - 30 kA powering capability
 - Magnets up to ~0.6 m diameter, ~3.6 m length



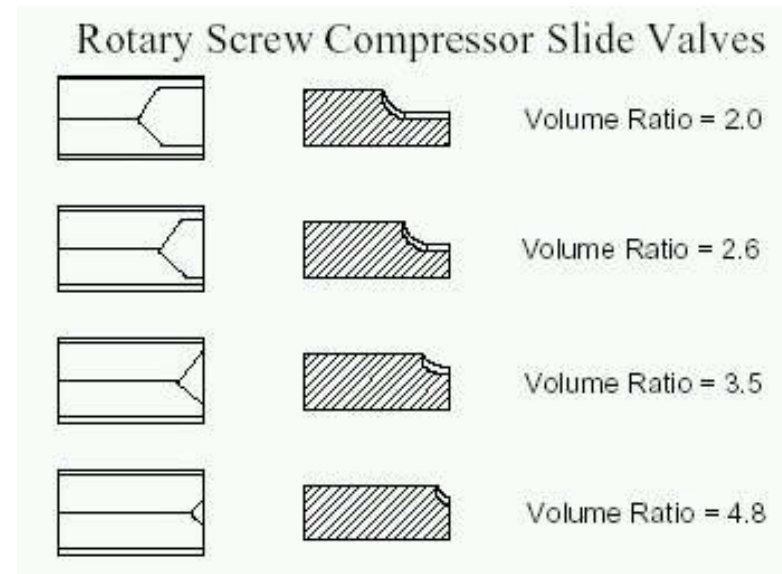
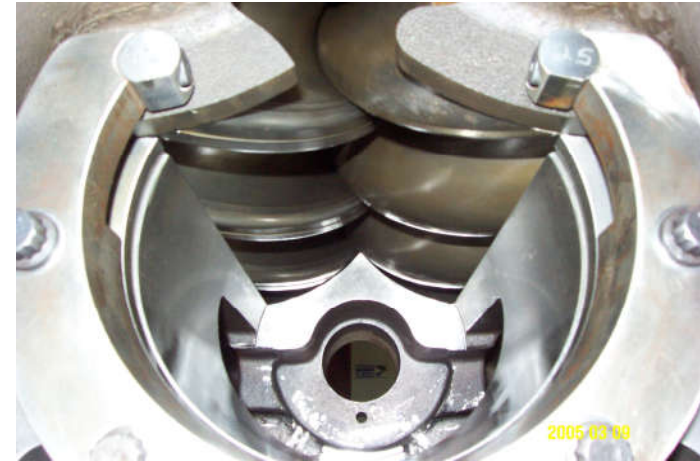
Vertical Test Facilities

- Vertical Cavity Test Facility (VCTF)
 - Three vertical dewars, saturated LHe baths
 - Vertical Test Stand 1 (VTS-1)
 - Commissioned in 2007
 - 26.3 in (0.67 m) inside diameter
 - LHe bath 80 in (2 m) deep (typ.)
 - ~700 liters of sat. 2 K liquid
 - VTS-2 and VTS-3
 - Commissioned in 2014
 - 36.3 in (0.92 m) inside diameter
 - LHe baths 80 in (2 m) depth (typ.)
 - ~1400 liters of sat. 2 K liquid
 - 2 ft (0.61 m) greater usable depth
 - Stacked cavities



Cryogenic Infrastructure Improvements

- Compressor Slide Valve Change
 - Replaced 1st stage slide valve
 - System stability



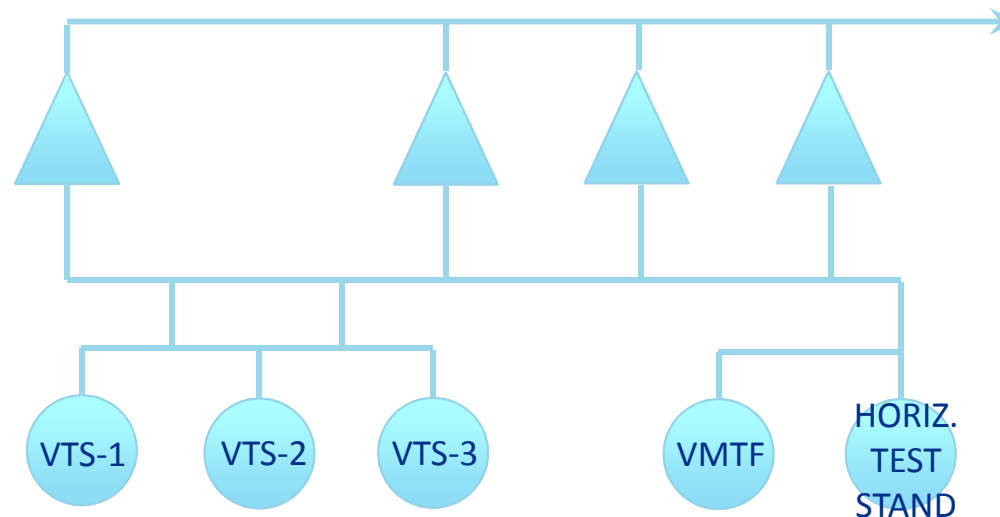
Cryogenic Infrastructure Improvements

- Gas storage installed
 - In 2008, added three 30,000 gallon helium gas storage tanks.
 - 4 of 6 tanks are plumbed at each end.
 - Operational availability: 6 storage tanks matches GHe storage capacity with LHe storage dewar capacity
 - VCTF and VMTF upset this balance.
 - Operational availability: allows continuous purification of GHe inventory



Cryogenic Infrastructure Improvements

- Additional 2 K pumping capacity installed
 - Operational efficiency
 - Redundancy
 - Flexibility



Cryogenic Infrastructure Improvements

- Each skid has a Roots blower backed by a liquid ring pump
 - 3.75 g/s at 31 mbar inlet pressure ($T_{\text{sat}} = 2 \text{ K}$)
- Local and remote control



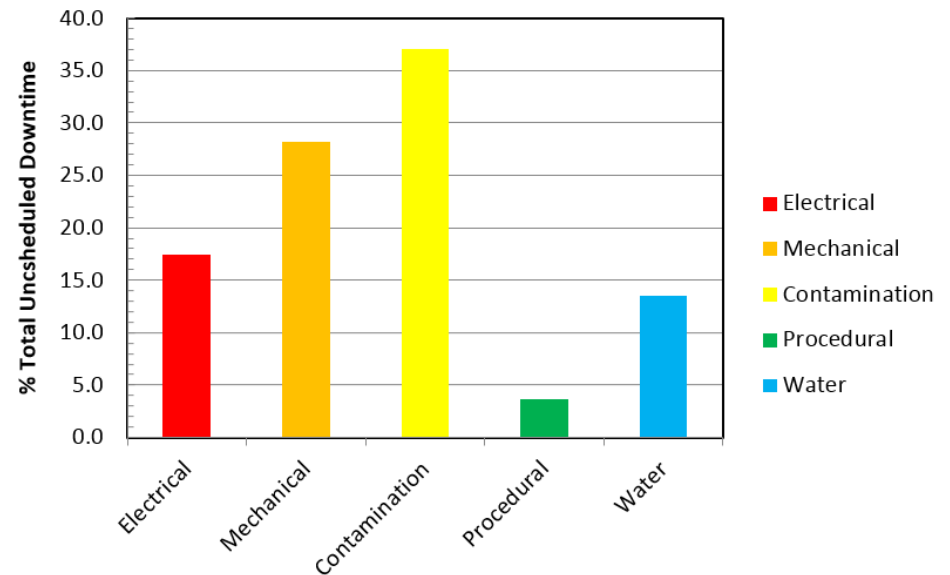
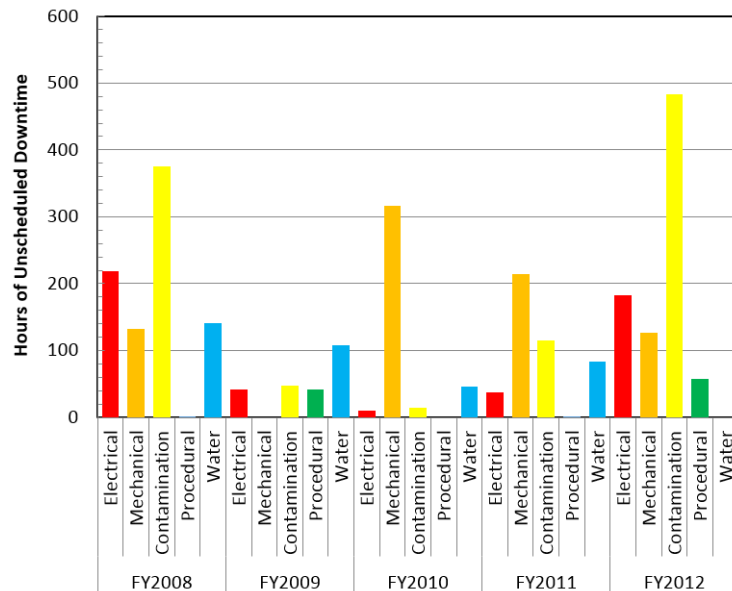
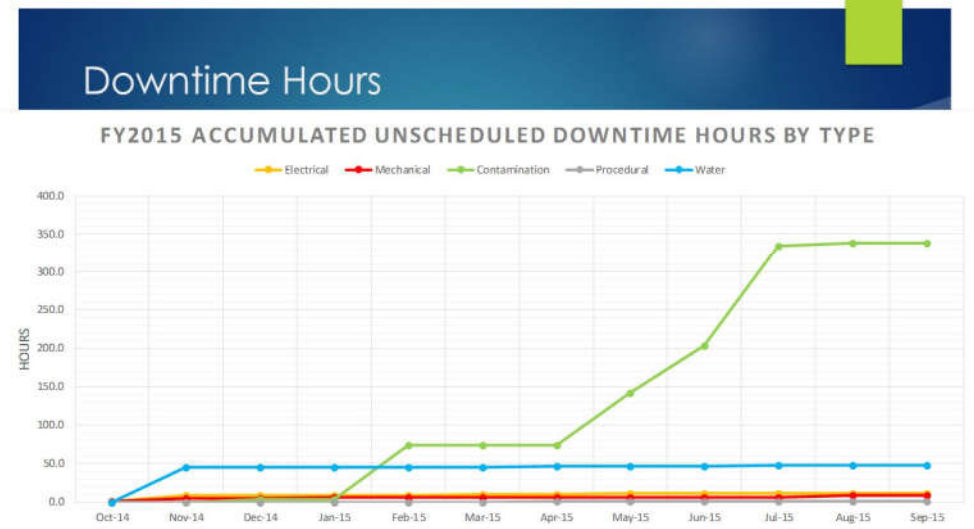
Vertical Test Facilities Improvements

- Helium recovery installed
 - Recover helium gas after quenching high stored energy (>1 MJ) superconducting magnets in VMTF.
 - Previously had to vent helium to atmosphere ($\sim \$1.2\text{k}/\text{quench}$, 50 quenches/magnet test typ.).
 - Solution was to reconfigure (when necessary) one of our six helium gas storage tanks as a quench tank. Operational in June 2012.



Operations Issues and Resolutions: Contamination

- Contamination statistics



Operations Issues and Resolutions: Contamination

- Sources and mitigation
 - Fittings
 - Positive pressure venturi effect
 - Subatmospheric
 - Pump and backfill operations
 - Normal operations
 - Eliminate compression fittings
 - Rupture disks
 - Pin holes
 - Ruptures due to system upsets



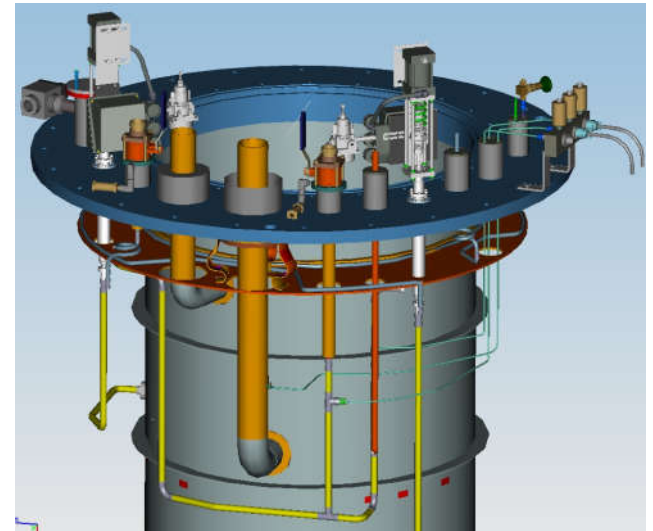
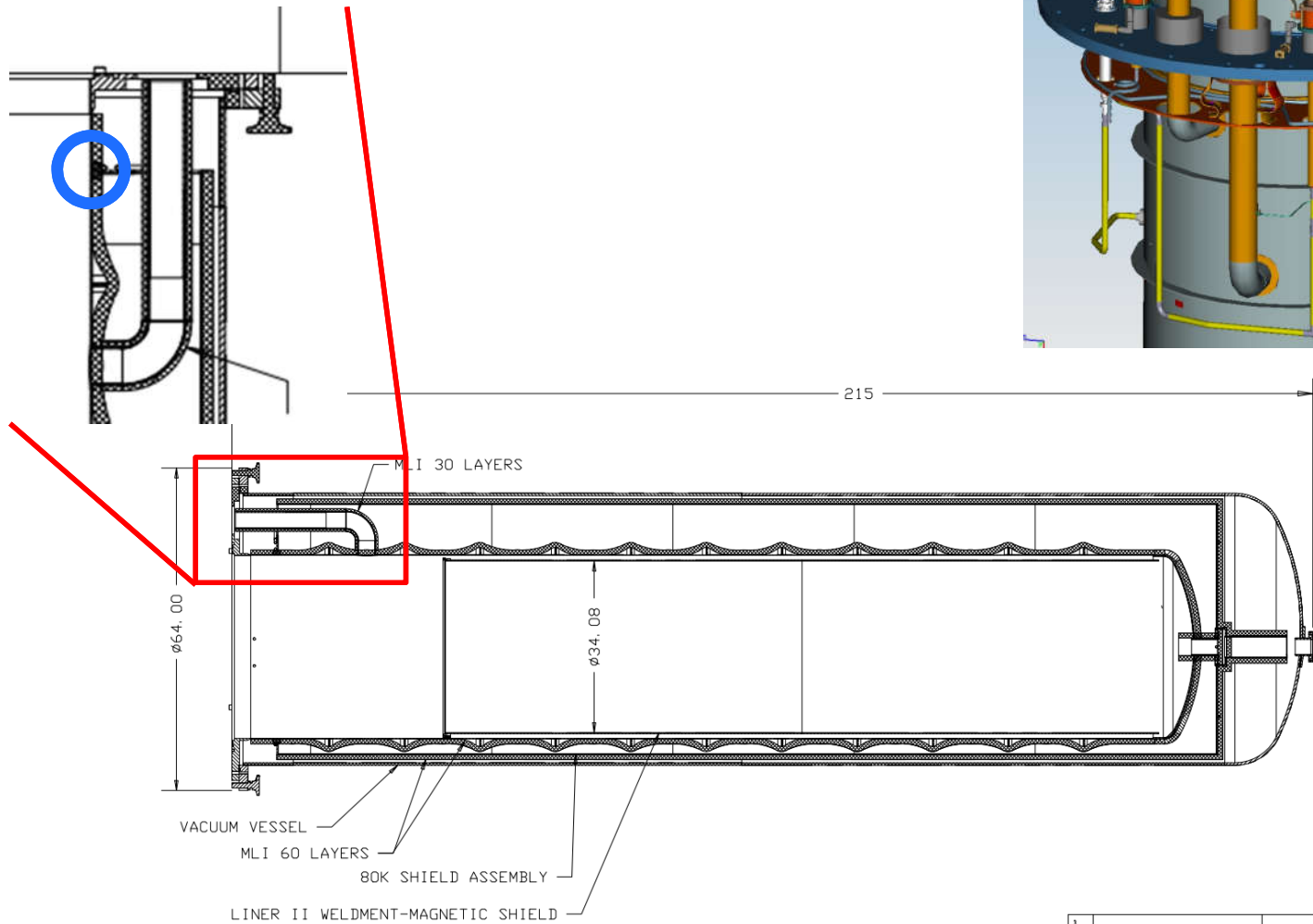
Operations Issues and Resolutions: Contamination

- VMTF magnet cool-down clamshell HX



Operations Issues and Resolutions: Contamination

- Water frost ring inside VTS cryostats



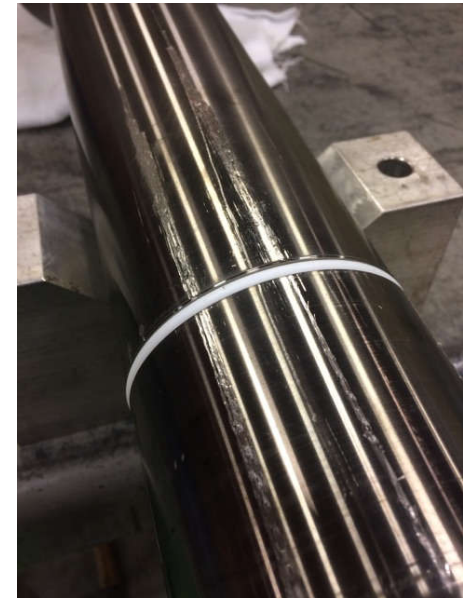
Operations Issues and Resolutions: Contamination

- System-wide contamination mitigation
 - 60 g/s Mycom compressor and two LN2-cooled charcoal bed purifiers being added to the IB1 system
 - Process all flows (pumped, subatmospheric flows and positive pressure flows) from Vertical Test Facilities



Operations Issues and Resolutions: Valves

- Valves: galling between valve stem and valve body ID
 - Valves hardly used. Manufacturing defect? Debris?
 - Honed/polished the jacket IDs
 - Turned down the stem ODs and had them chrome-plated. Radial gap increased from 0.005 in to > 0.010 in.



Summary

- A number of measures have been taken to increase the availability, efficiency, and flexibility of the IB1 cryogenic system.

Questions?